will be spreading themselves over the length and breadth, or the height and depth, of Switzerland. Many of these will be naturalists more or less acquainted with the Alpine insect fauna. To those who have already made its intimate acquaintance and are competent to distinguish the majority of the species in the field, this work will prove invaluable for consultation on the spot; to those who leave the determination of their materials until arriving home it will add interest to a not otherwise always enjoyable occupation.

In these latter remarks we have endeavoured to make it attractive to the numerous naturalists who are more or less amateurs. But its claims for careful study by those who are working at geographical distribution as a special branch of science, and at the philosophical speculations that such studies give rise to, are indisputable, and cannot be neglected. R. McLACHLAN

WORKS OF JAMES MACCULLAGH

The Collected Works of James MacCullagh. Edited by Professors Jellett and Haughton. Dublin University Press Series. (Dublin: Hodges, Figgis, and Co.; London: Longmans, Green, and Co., 1880.)

THE admirable practice of building a monument to departed men of science from the original works they have left behind them is steadily gaining ground, and is now indeed almost the rule. The collected works of Green, Rankine, Wheatstone, Cavendish, Graham, and Clifford have been comparatively recently published; those of Maxwell are being edited.

When the papers republished have been written many years the judgment of editors must be severely exercised; the temptation to point out the relation of the work of the original author to subsequent discovery is great, but the difficulty of deciding how much to add is greater. The late Prof. Maxwell in his edition of Cavendish added much of his own, thereby increasing manyfold the value and interest of the book, and at the same time more clearly exhibiting the penetration and genius of Cavendish. In the volume before us little of annotation and nothing of criticism is added, the work is left to speak for itself.

Nearly two-thirds of the book is occupied by the first part, containing the papers on Physical Optics. These are twenty-three in number. The first four deal with the geometrical treatment of Fresnel's theory of biaxal crystals. Unfortunately MacCullagh failed to perceive, or at least to point out clearly, the remarkable experiment of conical refraction, so soon after predicted by Hamilton and verified experimentally by Lloyd.

The method of the sixth paper, on the "Laws of Reflection from Metals," is characteristic, as we find a somewhat similar treatment of the theory of transmission of light in quartz and to some extent in the dynamical theory of double refraction. There is no pretence to a firm foundation on mechanical principles. A formula is assumed, the physical meaning of which is not apparent, and the deductions from that formula are interpreted. Fresnel's formulæ for the intensities of the reflected and refracted rays in the case of an ordinary transparent medium are taken as a starting point. It is further assumed without attempt at physical interpretation that the velocity of propagation of waves in a metal is $m(\cos\chi + \sqrt{-1}\sin\chi)$. The real value of the method may perhaps be best shown by trying to interpret this apparently unmeaning assumption. Passing over the difficulties in Fresnel's method of interpreting $\sqrt{-1}$ as extended by MacCullagh, we have on the assumption of the paper—

$$\zeta = A\sin n\{x - tm(\cos\chi + \sqrt{-1}\sin\chi)\}$$

or which is equivalent—

$$\begin{aligned}\zeta &= A\sin n\{x(\cos\chi - \sqrt{-1}\sin\chi) - mt\}\\ &= A\{\cos\sqrt{-1}\,n\sin\chi x + \sqrt{-1}\sin\sqrt{-1}\,n\sin\chi x\}\\ &\qquad \times \sin n\{x\cos\chi - mt\}\\ &= A\,e^{-n\sin\chi x}\sin n\{x\cos\chi - mt\}.\end{aligned}$$

The physical meaning of this equation is obvious, it clearly means absorption in the metallic medium. MacCullagh's theory of metallic reflection would bear the same relation to a theory resting upon the fact of absorption in the metal that Fresnel's theory of total internal reflection does to Green's.

In the seventh paper, "On the Laws of the Double Refraction of Quartz," we find the same method of treatment. Without any reason of a mechanical nature two equations of motion are assumed, viz.:—

$$\left.\begin{aligned}\frac{d^2\zeta}{dt^2} &= A\frac{d^2\zeta}{dz^2} + C\frac{d^3\eta}{dz^3}\\ \frac{d^2\eta}{dt^2} &= B\frac{d^2\eta}{dz^2} - C\frac{d^3\zeta}{dz^3}\end{aligned}\right\}$$

and the integrals of these are shown to express experimental facts. Subsequently Maxwell has obtained for magnetic rotatory polarisation the equations—

$$\left\{\begin{aligned}\frac{d^2\zeta}{dt^2} &= A\frac{d^2\zeta}{dz^2} + C\frac{d^3\eta}{dz^2dt}\\ \frac{d^2\eta}{dt^2} &= A\frac{d^2\eta}{dz^2} - C\frac{d^3\zeta}{dz^2dt}\end{aligned}\right.$$

It is interesting to remark that each system is strictly appropriate to the case to which it is applied. MacCullagh's equations do not apply to magnetic rotation of the plane of polarisation, for there the direction of rotation is reversed if the ray be reversed. On the other hand Maxwell's equations are not to be applied to a solution of sugar or to quartz. The distinction has been overlooked by Verdet, who treats both sets of equations as appropriate empirical formulæ for magnetic rotation; it is perhaps not surprising that Maxwell's fitted those facts the best.

MacCullagh's fame as a physical optician rests mainly upon the well-known paper entitled "An Essay towards a Dynamical Theory of Crystalline Reflexion and Refraction." This is the fourteenth paper of the series. Its position, in relation to the theories of Green and Cauchy, has been very ably examined by Prof. Stokes (British Association Report, 1862). But the appearance of Maxwell's theory of the transmission of light leaves room for a reconsideration of Stokes's criticism. The real point of MacCullagh's position may be shortly stated. In order to obtain his differential equations he must ascertain the form of the function V which expresses the work done in causing a given deformation of the medium which transmits radiation. His reasoning is obscure, but it virtually amounts to this. Let $\xi\,\eta\,\zeta$ be the displacement at the point $x\,y\,z$ of the medium, and suppose a plane

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wave propagated through it. If under these *particular* circumstances the quantities—

$$\frac{d\zeta}{dy}-\frac{d\eta}{dz},\ \frac{d\xi}{dz}-\frac{d\zeta}{dx},\ \frac{d\eta}{dx}-\frac{d\xi}{dy},$$

are given at each point, these three quantities are in general sufficient to define the direction of the normal to the wave front and the direction of disturbance. Hence—and here is the fallacy—the *general* expression for V must be a function of these three quantities. MacCullagh was probably unaware that these three quantities simply defined the angles through which the element about the point xyz was rotated by the displacement. That his expression for the function V not only rests on wrong reasoning but is actually wrong, for the case in question, where V is supposed to depend upon *the change of form* of the elementary parallelepiped, is easily seen. Suppose the deformation to be irrotational: through a given space on MacCullagh's theory V vanishes: but we know it may be anything we please. Again, suppose the medium within a given space to be simply turned through a given angle without change of shape: MacCullagh gives a finite value to V: but we know that in this case V is zero. It is a pity that MacCullagh did not keep to the method of his papers on metallic reflection and on transmission in quartz, and simply say, without admitting that V depends on the change of form of the elementary parallelepiped, "let us assume that V is a quadratic function of $\left(\frac{d\zeta}{dy}-\frac{d\eta}{dz}\right)$, &c." His theory would then have had a certain amount of analytical similarity with Maxwell's theory of electromagnetic propagation of light, though giving not the slightest adumbration of the physical basis of that theory, the facts which it covers being almost unknown when MacCullagh wrote. MacCullagh's expression for V as a theory regarding the ether as an elastic solid is misleading, but we are certainly not compelled to be so materialistic. To the student of physical optics we should say, first read Green, then read and criticise MacCullagh and Cauchy, and finally read Maxwell, not once or twice only, but until you understand him.

OUR BOOK SHELF

On the Structure and Affinities of the Genus Monticulipora and its Sub-genera. By H. Alleyne Nicholson, M.D., D.Sc., &c., Professor of Natural History in the University of St. Andrews. Pp. 240, and vi. Plates. (Edinburgh and London: Blackwood and Sons, 1881.)

THIS is a most elaborate work, on one of the most puzzling groups of palæozoic fossils, by the accomplished and industrious Professor of Natural History at St. Andrews. He gives the general history and literature of the genus, describes the morphology, dealing carefully with the dimorphism of the corallum, treats of the development of the forms, and compares them with Heteropora amongst the Bryozoa. Then the affinities of Chætetes and Stenopora are considered, and those of the Helioporidæ also. A chapter is devoted to the sub-divisions of the genus and to the consideration of the propriety of separating from it Fistulipora, Coustellaria, and Dekayia. Finally five chapters are occupied by the consideration of as many sub-genera. Yet the author modestly says that it is not a monograph of the Monticuliporidæ! The book is particularly valuable on account of the mass of careful description it contains, and the plates and cuts are excellent, and everybody who has tried to make out these tubular fossils will be grateful to Prof. Nicholson for his work. Like most palæontologists, he has suffered from the fact that his predecessors have described genera and species from very imperfect specimens. This is the curse of modern palæontology, and a clean sweep should be made of every classification which is not clear and definite, and which was founded on bad specimens. The difficulty of the subject taken up by the author may be appreciated by noticing the synonymy of the species; and it is interesting to notice how recent investigations by Busk, Waters, and Moseley are influencing the palæontology of very remote ages.

The author states that in *Monticulipora* there are no septa, and the walls are imperforate, whilst in *Heteropora* the walls are traversed by a very remarkable and exceptionally developed canal system; hence he separates the groups, but states—"In the face of the above distinctions I feel compelled to believe, in the meanwhile, that there is no real relationship at all between *Heteropora* and *Monticulipora*." "On the other hand there are strong resemblances between *Monticulipora* and its allies and various undoubted corals—principally perhaps the *Helioporidæ*." "I am at present disposed to regard the *Monticuliporidæ* as ancient groups of the *Alcyonaria*."

P. M. D.

The Evolutionist at Large. By Grant Allen. (London: Chatto and Windus, 1881.)

WIDER and wider grows the field over which newspapers and magazines exert their distributive influence. Verily, they sow beside all waters, and great is the variety of the seed. Their readers find a royal road to learning the contents of books which they are too hurried to read in full, in short essays which collect the essence, omit the difficulties, and state the conclusions of the writers in the clearest and most unqualified terms. It is satisfactory to find that an effort is made to supply modern science to such readers from competent pens.

Mr. Grant Allen has collected into this engaging little volume a series of well-judged attempts to perform this which have appeared in the *St. James's Gazette*, and no reader who would consult that class of publication for scientific ideas could help being interested and, we should hope, led on to further inquiries by it. Mr. Allen describes himself fairly when he says (p. 109), "I am not a butterfly-hunter myself. I have not the heart to drive pins through the pretty creatures' downy bodies, or to stifle them with reeking chemicals; though I recognise the necessity for a hardened class who will perform that useful office on behalf of science and society, just as I recognise the necessity for slaughtermen and knackers. But I prefer, personally, to lie on the ground at my ease and learn as much about the insect nature as I can discover from simple inspection of the living subject as it flits airily from bunch to bunch of bright-coloured flowers." And any one who sympathises with such feelings will delight in the company of "The Evolutionist at Large."

Nearly all the fresh lights which have been thrown upon the relations of the natural world by the teachings of Darwin and Herbert Spencer are here condensed and exhibited in the most simple gossipping style; while it is hardly necessary to say that the most puzzling questions that remain unanswered will suggest themselves on many a page of such an author's book. His disquisitions on the extent of animal feeling (p. 50), upon the origin of two eyes and the cross-connection of them and other organs with the brain (p. 102), are very interesting. But the most striking question which time after time turns up, as we might expect in such a book by Mr. Grant Allen, is the origin of our æsthetic sense: and since the sense of beauty is little else than a feeling of harmony with and admiration for the forms, colours, and adornments of flowers and animals; and as these are all the result of their selection by animals in choosing their haunts and their mates, we are landed at the rather humiliating con-

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